culiar form, are very interesting; because, in the white ones, the striations of the outer lamina, which form the corrugations seen in sections of the scales (fig. 5, *d*), are longitudinal, while the lower lamina, or lamina toward the insect, although smooth, shows transverse bands (fig. 5, *b*, *c*). In the fact of their corrugated surfaces being turned away from the insect, the scales of Alaus and of some other Coleoptera agree with the scales of Lepidoptera and Diptera. The 2-7 pointed scales of Ptinus (fig. 6), which are nestled amongst its hairs, resemble in a general way the plumules of some Lepidoptera. Most of the coloration of the well-known locust-borer, Clytus robiniae, is due to scales (fig. 7), which are of a form not rare in the longicorn Coleoptera.

The Rhynchophora or Curculionidae are the beetles on which scales most generally occur, and where they present their most brilliant coloration. The diamond beetle of South America, Entimus imperialis, often sold by jewellers on account of its brilliancy, has scales (fig. 8) and hairs which present to transmitted light various colors — usually red, blue, and yellow; often all three colors with gradations between them — on a single scale. By reflected light, or upon a black surface like that of the beetle itself, the prevailing colors are green and purple. The colors which are indicated by the direction of the lines on the figure (fig. 8 *a*, *c*) are those seen by transmitted light. When highly magnified, these scales, besides other structural characters, show a very fine striation (fig. 8, *d*, *e*), sometimes in one direction on one part of the scale, and in another direction on another part. This fine striation is probably the cause of the brilliant coloration of these scales.

All the brilliant coloration of scales of Coleoptera appears to be due to interference of light, either by fine striation, or by superposed delicate lamellae; as can be proved by wetting the scales with chloroform, when the color disappears, only to reappear as soon as the chloroform is evaporated. Most of the scales of Coleoptera contain air; and this air, together with the background formed by the coloration of the insect itself, gives rise to the various changeable hues seen in most of the Coleoptera which have scales.

MICROBES.[1]

NONE of the organic substances which form an essential part of our sustenance, and are useful in a thousand ways, can be kept for more than a few days: fermenting and spoiling, they are the despair of the economists. In this decomposition the substance becomes filled with an immense number of very minute organisms. How can a liquid, like milk or soup, free from all foreign germs, become invaded in a few hours by these innumerable legions of microbes? The first hypothesis suggested is, that all these organisms are the result of the decomposition, and that they are produced spontaneously at the expense of the altered substance. This is the theory of spontaneous generation, so vigorously maintained by Pouchet; and it is certainly one of the greatest of Mr. Pasteur's good offices, that he has refuted one by one the arguments of the supporters of this attractive theory, pursued them to their last defence with his invincible logic and his unexceptionable experiments.

The fermentation is produced by the microbes; and these, by a wonderfully rapid propagation, are derived from germs carried by the air, or adhering to the vessels which hold the fermentable liquids. The diligent researches of Mr. Miquel show that the comparatively pure air of the suburbs of Paris holds from a hundred and fifty to a thousand living germs per cubic metre. In a hospital at the centre of the capital, each cubic metre of air contains from five thousand to thirty thousand, according to the season. Although these figures appear prodigious, they are nevertheless very small, compared to the number of spores which cling to all the solid objects surrounding us. A simple cleansing is powerless to remove them: only fire or strong antiseptic solutions can destroy them. A fermentable liquid can be preserved indefinitely if it is protected from all microbes; but it is easily seen, after what we have just said, how difficult it must be to obtain this perfectly insulated state. All these lower vegetable types are found in two forms, — 1°, the vegetative or active form; and, 2°, the passive form, that is, the spores, which play here a part analogous to that of seeds in plants.

In the active state most microbes show little endurance; many species cannot stand a drying of any duration; and in moisture a temperature of 70° to 80° C., continued for two or three hours, destroys them almost without exception. Spores are more hardy: boiling water does not kill them; but, for this purpose, water must be heated to 120°, 130°, and even 150°. When dry, the spores do not succumb to a temperature below 180° to 200°; and, according to Mr. Fricz, cold of 110° has no effect upon them. To disinfect clothing without burning; would, then, be an impossibility, if, fortunately, Mr. Koch had not discovered that the germs cannot resist the action of a continued current of steam at a temperature of 100°.

It is peculiarly difficult to protect a liquid from all germs, or to destroy all those which have penetrated it; however, it is possible, and the liquid is then said to be *barren*. Certain soups are prepared in this way that they may be sown with very small particles of substances containing the microbes to be studied; and thus the desired species obtained, to the exclusion of every other. Laboratories devoted to these studies annually distribute hundreds and thousands of litres of these soups.

The organisms which here claim our attention belong to three families, all allied to fungi, — moulds, yeasts, and microbes proper. Each kind of fermentation is produced by a certain species of these small organisms, and takes place only if the species in question is present in the liquid, from the beginning of the fermentation, in sufficient numbers not to be

[1] By Dr. H. FOL of Geneva. Translated from the *Journal de Genève*.

choked by other species. Thus the mycoderm of wine is found in abundance in the flower of the bitter grape, and is naturally scattered in the must which flows from the press. In Japan the vine grows with wonderful rapidity, and bears magnificent grapes; but the mycoderm is lacking, and the fermentation produced by the other microbes yields only an undrinkable liquid. The bakers and brewers know very well how to introduce into their dough and must the species needed. Without microbes, milk would not curdle, cheese and vinegar would be unknown; the vegetable *débris* would not decompose, and there would be no loam. Some one has calculated that a gram of soil contains a million of these little creatures. We are so accustomed to associate the word ' microbes ' with the most dreaded diseases, that we lose sight of the important part they play in nature. We can confidently say that their suppression would completely overthrow the present order of things.

The power of causing fermentations is certainly one of the most curious phenomena which these lower vegetable types present. This power belongs only to certain species. Mr. Pasteur was the first to discover that certain microbes live in the air, and breathe like animals: these do not produce fermentation. Others live only when protected from the air, and cause fermentation in the matter which contains them. To these two classes there has recently been added a third, amphibious microbes, simply vegetating while in the air, and producing fermentations only when the air is withdrawn. Fermentation thus seems to be a kind of respiration. The yeasts decompose liquids in order to obtain products rich in oxygen, which take the place with them of respirable air. These facts are highly important in explaining the mechanism of diseases.

In short, from a practical point of view, we may divide microbes into three classes, — those which are useful, those which seem to have no effect, and those which are positively harmful. We have already mentioned the first class; the second are very numerous; for, to say nothing of the many species which inhabit all the recesses of nature, and concern us only very indirectly, we undoubtedly support quantities of them in the cavities of the surface of our bodies and of our digestive canal. Nothing equals the astonishment and confusion of very solicitous persons, when, by a turn of the hand, the micrograph shows them all the various forms which live at their expense. They are all kinds, from the harmless Spirillum in the saliva to the Leptothrix, which is the most active agent in the decay of teeth. But all this is on the surface: the interior of our bodies is completely free from them; and it may be said that in our organization every means is taken to defend the entrance to the organs from ordinary microbes, and to remove them if they succeed in forcing entry. There is, however, a certain number of species which have the sad privilege of being able to penetrate and support themselves in the body of a subject predisposed to receive them. The microbe of septaecemia enters only through an open wound, while those of tuberculosis and leprosy attack directly the lungs or mucous membranes of the persons afflicted. The surfaces of the lungs and of the alimentary canal seem to be the customary points of attack for the organisms which cause various infectious diseases.

Our organization is like that of a civilized nation, whose citizens are represented by our cells. The skin becomes broken (the wall of China discloses a breach), and immediately there are hordes of savage microbes which enter, at strife with the national soldiers (our cellular tissues). The microbes multiply, and scatter around a poisonous liquid; the cells combine, and try to starve their dreaded enemies and to repair the breach. The battle-field is small; but the victory is warmly contested, and the sight has its exciting aspect. The result of the struggle depends on the number of combatants and on the energy of the competing forces. The antiseptic treatment of wounds, as at present skilfully used by Professors Julliard and Reverdin, and Dr. A. Reverdin, aims to reduce as much as possible the number of microbes which enter, and to retard their development; for no one familiar with the subject would think it possible to entirely exclude them. How interesting it would be to trace the events of the contest between the organism and its invaders in the case of an epidemic disease! Science, we hope, will soon be in condition to give us this history.

The diseases which have been traced with certainty to parasites are as yet few in number: they may be counted on the fingers. To discover the nature of a disease, there must be a uniformity of experiments and evidence, of which the public, and even the majority of specialists, take no account. Nothing is easier than to examine with a microscope small parts of the various organs of a dead body, and attribute the fatal disease to the microbes found under these circumstances. These would-be discoveries, soon disproved, have only the effect of causing the public to mistrust useful investigations, and cast undeserved discredit on serious work performed in the most methodical manner. To know a parasitic disease, it is not enough to have seen the pathogenic microbe: it must have been removed from the other microbes, and cultivated through a long series of generations in sterilized soups; animals must be inoculated at various times with these pure types, and each time all the symptoms of the disease whose cause is sought must be observed. In this way Mr. Koch has revealed the microbes of charbon and tuberculosis; and these discoveries have been granted to science, after being examined by a number of investigators, among them Professor d'Espine. Long and very careful cultivation was necessary to show, after Dr. Haltenhoff's interesting paper on this subject, that the juice of the *jequirity* owes its extremely virulent properties only to the microbes which it contains. We know quite satisfactorily the organisms which produce leprosy, erysipelas, and symptomatic charbon; but for diphtheria, typhus, intermittent fevers, and many other diseases, the agents are still undiscovered.

Intermittent fevers afford a good example of how easily errors arise and spread. They were at first, and

without sufficient evidence, said to be caused by the palms, — comparatively high vegetable types, perfectly innocent of the crime of which they were accused. Late investigations point to a bacterium of elongated form as the cause, but the proofs are still insufficient. To learn to recognize the enemy is certainly the most necessary thing to be done, but it is only half the task: we must then learn to resist it. The more or less effective means of combat which have been employed up to the present time have aimed, 1°, to prevent the dissemination of dangerous microbes; 2°, to make the organism unsuitable for the propagation of the intruders; 3°, to retard, as far as possible, the growth of those which have entered, in order to give the organs opportunity to throw them off. The first of these measures engrosses the attention of the hygienists: hospitals, quarantines, and disinfectants are among the means employed. I will not enter upon a subject which touches so many disputed questions, but will confine myself to noticing certain facts and to rectifying certain very wide-spread errors. Regarding infection, the nose is a poor guide; for the experiments of Mr. Miquel show very distinctly that substances in a state of putrefaction, so long as they are moist, do not emit living germs. The water of the Paris sewers holds eighty million microbes per litre; and yet the air of the sewers contains only eight hundred or nine hundred germs per cubic metre, about one-tenth the number found in a hospital. By inoculating a rabbit, it was shown that these germs are perfectly harmless. The moist earth does not give out living organisms to the atmosphere. On the contrary, the dust of our rooms, which we do not at all mistrust, shows about two millions of these living germs per gram. The bacteria of intermittent fevers, which vegetate in the soil of the Roman Campagna, begin to spread in the air and to become dangerous only when the soil, dried by a scorching sun, is raised by the wind in the form of dust. It would be easy to multiply examples, and to prove, that, in point of hygiene, we must be guided by sense rather than by smell. We have as yet but begun this kind of study; for how does this total number of germs which the air or water holds interest us? We would prefer to know the number of dangerous germs. The proportions would doubtless be very different from those which concise analysis affords.

Until we are better informed, we shall do well to push cleanliness to an extreme, and especially to put little trust in disinfection. The number of subtances which are less injurious to man than to micro-parasites is very small. The best disinfectant is perfectly useless if too weak a dose be used. For each of these substances there is one proportion which will destroy the germs, and another which will arrest their vegetation but not destroy them. This last dose is the one with which we are generally obliged to content ourselves. The experiments of Mr. Koch and Mr. Miquel show that the narcotic effect begins to be effective on microbes only when the substance in which they are vegetating contains, among a thousand parts, 95 parts of alcohol, or 70 of borax, or 10 of salicylate of soda, or 3.2 of phenic acid, or 5 of quinine, or 0.6 of bromine, or 0.07 of bichloride of mercury, or 0.05 of oxygenated water. Certain of the substances indicated are useful in these doses; while others, as bromine, are impracticable. But especially let us not forget that the result is not a radical disinfection: it is merely a momentary weakening. Is it still needful to insist on the uselessness of too mild doses? We are constantly seeing phenic acid used at less than one in a thousand parts with the sole effect of creating a mistaken sense of security. Let me mention another almost unknown antiseptic: essence of terebinthine, according to Mr. Koch, arrests the vegetation of microbes in a dose of $\frac{1}{75000}$, a quantity easily endured by man.

All these hygienic precautions are bristling with difficulties. How convenient it would be to let the microbes live and to protect our bodies from their influence! Unfortunately we know but one way to effect this: it is based on a remark, made long ago, that certain diseases can be retaken only after many years, and that this freedom may be obtained by contracting the disease in a very mild form. This is the principle of vaccination, and also of inoculation, employed by Mr. Pasteur on certain animals. The matter inoculated contains the microbe of the disease from which we wish to protect the subject, but modified by a special cultivation: it is a virus weakened according to the methods of Mr. Toussaint and Mr. Pasteur. We touch here upon a question, at present much contested, in regard to the regularity of specific forms of these very low vegetable types. Mr. Zopf and the school of Munich believe that the most harmless species can, under certain circumstances, be changed into dangerous ones, and *vice versa.* The school of Berlin thinks that artificial modifications are only transient and momentary, and that the species may be considered invariable. However this may be, it is certain, that, if the inoculations of Mr. Pasteur have no great practical importance in their present form, they at least have a considerable theoretical value. We may hope that the time will come when it will be possible to vaccinate for all diseases which can seldom be taken a second time. Who knows if it will not end by discovering the nature of the influence which the parasitic invasion exerts on the tissues of our bodies, and in obtaining the same result in a more direct way without inoculation? When we consider the progress of science in the last half of the present century, we venture no longer to answer, 'Impossible.'

THE WATER-PORES OF THE LAMELLIBRANCH FOOT.

IN 1817 Cuvier showed that in Aplysia there was a closed vascular system, and claimed the same for all Mollusca. His view was followed till 1845, when Valenciennes and others described in many lamellibranchs pores which passed through the foot to introduce water into the lacunar tissue, where the blood circulates. This view found general acceptance, and